Original Research Article

Management of Iceberg Lettuce Quality

Abstract

In this study an attempt is made to understand the quality deterioration of iceberg lettuce during its supply chain i.e. during pre-harvesting, harvesting and post harvesting period. Further it was tried to identify the cost of cultivation of iceberg lettuce per hectare and the crop rotation followed by the farmers. The Nilgiris District of the Tamilnadu state was the study area for this research. For this study 30 farmers were selected for data collection based on convenience sampling. From these farmers during pre-harvesting, harvesting and post harvesting period each 10 samples of iceberg lettuce heads were taken for inspection and observations recorded during quality inspection. From the study it was fetched out that the major part of the quality deterioration takes place during post-harvest period. This paper focused on comparison of the quality parameters is done before dispatch and after, the knowledge of iceberg lettuce growing farmers.' It is identified with respect to the chemical application and spraying techniques used for growing of iceberg lettuce. These current practices of farmers with respect to the chemical application and spraying techniques are compared with the standard practices to identify the loopholes in the current practices of the farmers. It was found that the total cost of cultivation was 66745 rupees/acre.

Key words: Iceberg lettuce, quality, farmers, harvest, techniques and cost

1. Introduction

Lettuce (*Lactuca sativa*), a vegetable that belongs to the Asteraceae family, is popularly grown and consumed worldwide. The leaves are nutritious and contain more minerals and carotenoids, including beta-carotene. It adds less calories but contains more water, some fibre and folate (Reader, 2003). Iceberg lettuce is one of the most highly favorable fresh vegetables, being a traditional ingredient in salads, sandwiches, and other items found in self-service restaurants. Nevertheless, it is known that the quality of iceberg lettuce declines rapidly at ambient

temperature, which deeply limits storage and consumption of the vegetable. Deterioration of postharvest quality of vegetables could be inhibited by application of some treatments. As per the FAO (2017) report 17228 tonnes lettuce and chicory produced worldwide.

In the study of Fan *et al* (2003) lettuce treated with warm water and irradiated at 0.5 or 1 kGy had the best sensory quality without significant loss in texture, vitamin C, or total antioxidants.

The results of Johannessen *et al* (2004) indicated that the use of manure does not have considerable influence on the bacteriological quality of organic lettuce. However, others have suggested that there is a risk by using manure. Fonseca *et al* (2011) identified that common commercial conditions confirmed the enhanced risk of *E. coli* contamination when using sprinkle irrigation. Furthermore, *E. coli* persistence in furrow-irrigated soil validates the importance of an early irrigation termination for both sprinkler and furrow methods. Agüero *et al* (2011) studied about the quality and shelf-life of material stored at humidity condition was five days, when the overall quality scores of middle and external sections were below the acceptability limit and only the internal section had a score above the limit. In addition, overall quality of lettuce stored at optimal RH decreased slowly.

In this study an attempt is made to understand the quality deterioration of iceberg lettuce during its supply chain i.e. during pre-harvesting, harvesting and post harvesting period. Further it was tried to identify the cost of cultivation of iceberg lettuce per hectare and the crop rotation followed by the farmers.

1.2 Management of Iceberg Lettuce Quality

Pre Harvest Period

Harvest maturity: harvesting at optimal maturity, concerning achieving maximum yield and shelf-life. Martínez-Romero (2008) suggested that the natural fungicide might be an excellent alternative to the synthetic fungicides, and in turn to fulfill consumer requirements for more natural and healthy foods.

Irrigation management: Trickle irrigation can be used successfully to grow lettuce with higher water use efficiency than using sprinkler irrigation. Lettuce plants should be maintained free of water stress right up to harvest for maximum yields.

Planting density: To determine the optimum planting density and fertilizer input to maximize yields per ha.

In the study of Tudela et al (2013) suggested that visual quality of fresh-cut iceberg lettuce is important but so are odour and flavour. MAP currently used for fresh-cut lettuce may need some modification to inhibit off-odours and achieve better aroma and flavour qualities for preserving "freshness" of the cut product. Screening for cultivars with low browning potential and fermentation, harvested at optimum maturity stage and with an adequate package design are recommended

Post-Harvest Period

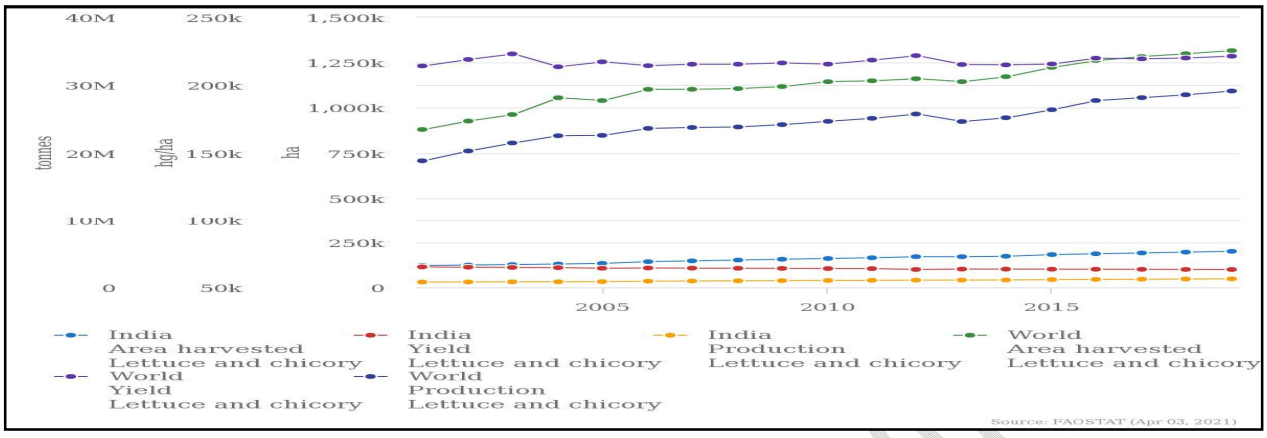
Harvesting at the correct time: Harvesting too late or too early will shorten the marketable life of lettuce. Harvesting early means less carbohydrate has been stored and harvesting late means that senescence (growing old) has already started in the field.

Cooling/Temperature management: The maximum marketable life of lettuce is achieved if the product is vacuum cooled within half an hour of harvest. Forced air cooling is a slow method of cooling and it is not the recommended method for cooling lettuce. The cool chain must be maintained from the farm gate to the consumer for best results.

Store lettuce as close to 0ºC as possible: Low temperature storage reduces the respiration rate of the product and this slows the rate of deterioration, metabolism and slows the rate of the development of rots. Avoid damage during harvest and handling: Damage after harvest promotes browning and rots. Removing the outer leaves of lettuce after harvest can extend the marketable life. Breaks in the cool chain can undo all the good work done on a farm: A reliable cool chain is a key step that shouldn't be overlooked. Mou et al (2012) studied that nutritional quality of lettuce may be influenced by environmental factors such as light, temperature, growing season, cultural practices, fertilizer application, post-harvest processing, and storage conditions. The moisture content of the plant also disturbs nutrient meditation. To improve the nutritional levels of vegetables would increase the nutrient ingestion without calling for an upsurge in ingestion.

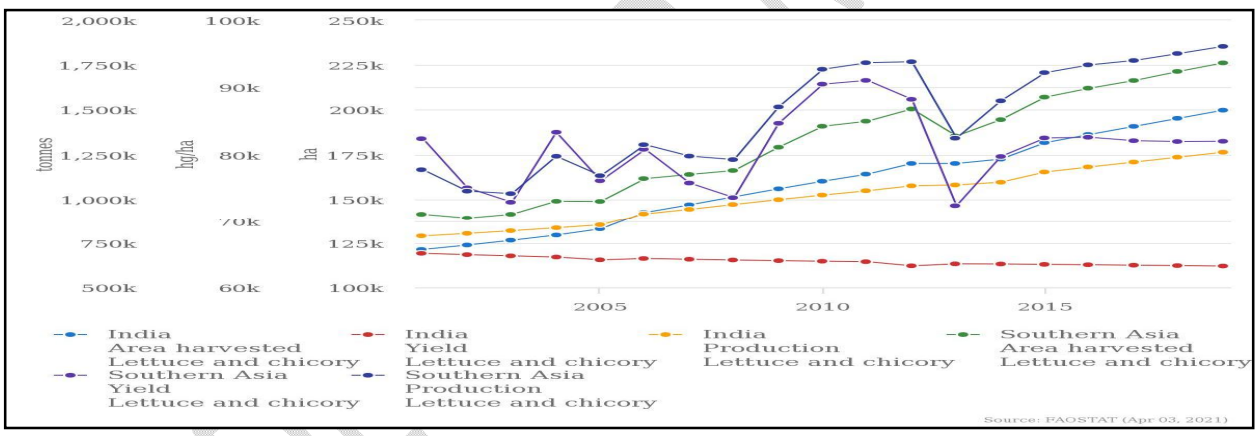
Iceberg lettuce is mostly preferred for consumption in the foreign countries in the form of salad. In worldwide production India is on 3rd position but with the comparison of worldwide area, production and yield India is far behind (Figure 1).

Figure 1: Area, Production and Yield of Lettuce and Chicory in World and India Comparison



Source: FAOSTAT (2017)

Figure 2: Area, Production and Yield of Lettuce and Chicory in South Asia and India Comparison



Source: FAOSTAT (2017)

In India, this exotic vegetable has gained popularity in recent years. Growing of the exotic vegetables like lettuce, broccoli, parsley and red cabbage has great scope and created cultivation interest among Indian farmers. The consumption is increasing day by day as India imports more than 85 percent of the exotic vegetables (Figure 2). In certain regions of India, exotic vegetable and fruit cultivation has become a profitable venture as compared to the Indian vegetables (Rao and Sasanka, 2015).

2. Literature Review

2.1 Empirical Review on the Impact of different chemicals on Iceberg Lettuce Quality

Several studies have been conducted to identify the impact of different chemicals on iceberg lettuce quality worldwide. The results of Gopal et al. (2010) revealed that both sources of silver (electrochemical silver and silver nitrate) have similar disinfecting effects, however, electrochemical silver maintained the quality of washed lettuce. Hoque *et al.* (2010) identified that the most economical treatment providing the highest yield and best post-harvest quality was the combination of 225 kg/ha N and 112 kg/ha P. A study conducted by Konstantapoulou *et al*., (2010) in south Greece concluded that the optimum nitrogen application rate for Cos lettuce grown hydroponically under cover during autumn and winter and in other area with a similar climate is 200 mg NL-1 because at this nitrogen rate the yield is satisfactory and leaf nitrate concentrates are below the maximum acceptable level for human consumption. Likewise, fresh cut Romaine and Iceberg lettuce salads of different commercial brands were obtained from both retail and wholesale stores. The packages were cut open at one end, the lettuce salad inoculated with E. coli O157:H7 via a fine mist spray, and resealed with or without an initial N2 flush to match the original package atmospheric levels Luo *et al.* (2010). A study by Luna et al. (2012) found that the effects of five drip irrigation treatments on the quality and shelf life of fresh-cut iceberg lettuce (*Lactuca sativa* L.) were examined in six different harvest dates during three consecutive years. The quality and shelf-life of the fresh-cut lettuce was better preserved by reducing the irrigation quantity during the growing period. The study of Palma-Salgado *et al.* (2014) found that the washing-before-cutting process recorded an E. coli O157:H7 count reduction 0.79–0.80 log10 CFU/g higher than that achieved with the cutting-before-washing process in treatments involving only a sanitizer. When ultrasound was applied to the washing-before-cutting process, a further improvement of 0.37–0.68 log10 CFU/g in microbial count reduction was obtained, reaching total reductions of 2.43 and 2.24 log10 CFU/g for chlorine and peroxyacetic acid washes, respectively. A study by **Galgano *et al.* (2017)** the shelf-life of fresh-cut iceberg lettuce, testing a packaging film manufactured with and without addition of anti-UV compounds, and using two different protective atmospheres (N2 / $_2$ 70/30 percent and Ar/ $_2$ 80/20 percent). In order to simulate the most common retail storage conditions, the samples were stored at 6 °C under artificial light by using real supermarket refrigerated exposition stands. The data showed that the use of an anti-UV film always causes a lower quality decay of the product; in any case, the best results were obtained when the anti-UV film was utilized in association with the packaging atmosphere consisting of Ar and $_2$ (80/20 per cent) gas mixture.

3. Material and Methods

The Nilgiris District of the Tamilnadu state was the study area for this research. Iceberg lettuce cultivation in Tamil Nadu is practiced in this district. The reason for selecting the Nilgiris district was that the area was more prominent and suitable for production of quality Iceberg lettuce. The climatic condition of the Blue Mountains is perfect for the cultivation of the exotic vegetables like Iceberg lettuce, broccoli, beetroot, leeks, Chinese cabbage etc. As Iceberg lettuce requires a cold climate and the climate of Nilgiris is suitable for Iceberg production. In Nilgiris district, there are several private companies which are doing contract farming to produce Iceberg Lettuce. For this study 30 farmers were selected based on convenience sampling. From these farmers during the pre-harvesting, harvesting and post-harvesting period each 10 samples of iceberg lettuce heads were taken for inspection and observations recorded during quality inspection. A structured schedule was used for data collection. For this study fields were visited on the weekly basis to check the insect load and other parameters like rotting, diseases etc. Visiting the harvesting fields to monitor the GHPs (Good Harvesting Practices) like wearing the hairnet, gloves, using sanitized knives etc.

4. Results and Discussion

4.1 Quality Inspection during Pre-Harvesting, Harvesting and Post Harvesting Period

The maintenance of quality and shelf life of the iceberg lettuce is important between the time periods of its production point until it reaches the ultimate consumer. To identify the changes observed in the quality of the iceberg lettuce during pre-harvesting, harvesting and post harvesting period of its life cycle.

During the pre-harvesting period, a visit to the iceberg lettuce is taken, which will be harvested in the next week to analyze the condition of the field. Careful observation of the iceberg lettuce was done to identify some defects like Rotting, insect pest attack, various diseases and improper head formation. Apart from the external observation, ten iceberg lettuce heads were collected randomly from the different parts of the fields to inspect those sample heads' quality. After the field observation and quality inspection of 10 heads, a report was prepared comprising the field observations and the observations made during the quality inspection of 10 iceberg lettuce.

Figure 3: Caterpillar Infestation

Figure 4: Rotting

Figure 5: Improper Head Formation

Figure 6: Leaf Minor Infestation

During the harvesting period based on the prior observations are done, the instructions regarding Good Harvesting Practices (GHPs) like maintaining sufficient stem length, outer dark green layers removal and placement of heads (to reduce the browning effect on the outer surface of the heads during transportation) were given to the harvesting team about how to harvest the fields. For example, if the field is severely infested with rotten pieces, the harvesting team was instructed to carefully see the head and cut the rotten free heads.

During post-harvesting period

At the dispatch centre, the harvested produce was pre-cooled for two hours at 4-5°C. After pre-cooling, the produce was unloaded from the cold storage and loaded into the refer vehicle, which will further supply the produce to the processing unit. During quality inspection at post-harvest period, 20 samples were taken from different crates, which will be dispatched on that day. After

selecting the 20 samples, they undergo quality inspection process, in which some quality parameters like

Maturity Index (Maturity index represents the correct maturity of iceberg lettuce. The maturity index is the density or compactness of inner layers within a head), Insect load (Insect load is the number of insect pests found within the heads during quality inspection), Browning (Browning will happen because of the fiction between the iceberg lettuce heads during transportation), Rotting (the rotten portion of all the iceberg lettuce heads is cut off and weighed separately.) and Outer dark green layer (the outer dark green layers should be removed as they are of no use) were tested for quality determination.

Table no. 1 Difference between the QIP at the Time of Dispatch and At the Time of Receiving at Mumbai

Quality Parameters (Avg)	30/05/2015		02/06/2017		05/06/2017		10/06/2017		15/06/2017	
	Disp		Rec		Disp		Rec		Disp	
Head Size (gm)	522	410	545	510	502	420	360	420	560	550
Browning (%)	0.8	2.3	2.4	5.1	1.8	5.2	0	0	0.7	2.1
Rottening (%)	1.4	4.3	0	0	0	0	0	0	0	0
Insect Load (%)	0	0.15	0.25	0.07	0	0.24	0.33	0.12	1.25	0.19

Source: Primary data

Table no. 2 Difference between the QIP at the Time Dispatch and at the time of Receiving at Bangalore

	9/06/2017		14/06/2017		19/06/2017	
	Disp	Rec	Disp	Rec	Disp	Rec
Head Size(gm)	428	330	500	430	550	430
Browning (%)	1	1.5	0.1	1.5	0.3	1.5

Rottening (%)	0.3	2	0.5	2	0.2	2
Insect Load(%)	0.3	1	0	0.1	0	0.16

Source: Primary data

4.2 Cost of Cultivation and Crop Rotation Followed by the Iceberg Lettuce Farmers

For calculation of standard cost of cultivation per acre and crop rotation practices related data were collected.

4.3.1 Cost of Cultivation of Iceberg Lettuce

Table 3: Cost of Cultivation of Iceberg Lettuce

Days	Field preparation	Seed material & transplanting	Irrigation	Weeding	Pesticide application	Fertilizer application	Harvesting
1				1050			
5				1050			
10					920		
20						550	
25						10125	
33					920		
35						3150	
38						550	
40					920	920	
42						3200	
58						2970	
Total	14700	19950	70	2100	2760	21465	3400
							64,495

Source: Primary data

Machinery hiring charges per day – 2250

Grand Total – INR 66745/Acre

If properly managed, the estimated cost of cultivation for iceberg lettuce per acre would be around Rs. 67000. The data has been collected from the company and it is the standard cost of cultivation which is cost effective with more production. As contract farming is going on in the study area, the average cost of cultivation of the farmer is also around ₹ 67000. The contract farming company is providing the necessary tools like insect traps, yellow sticky traps and chemicals for application to control insect pests and diseases. Hence farmer are purchasing very little amount of other chemicals and tools which are necessary for the cultivation of iceberg lettuce.

Hence the cost of cultivation of iceberg lettuce growing farmers' in the study area is almost similar and is around INR 67000. The contract farming company is also monitoring the field activities of the iceberg lettuce growing farmers to obtain the uniform and best yield possible.

4.2.2 Crop Rotation Followed by the Iceberg Lettuce Farmers

Fig. 7: Crop Rotation

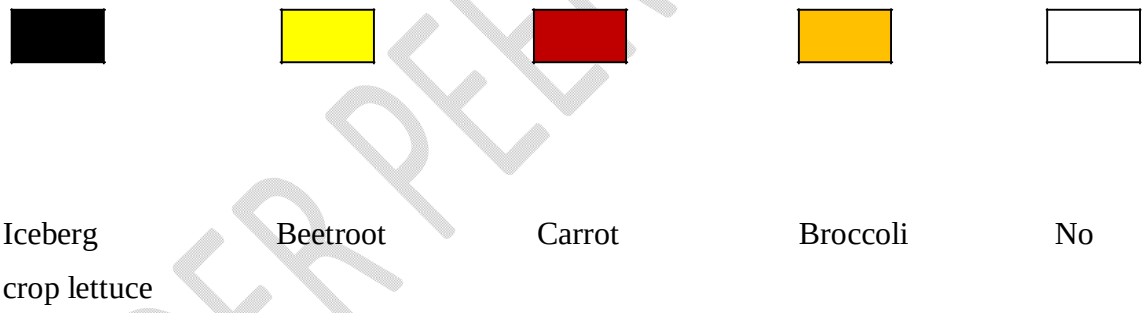
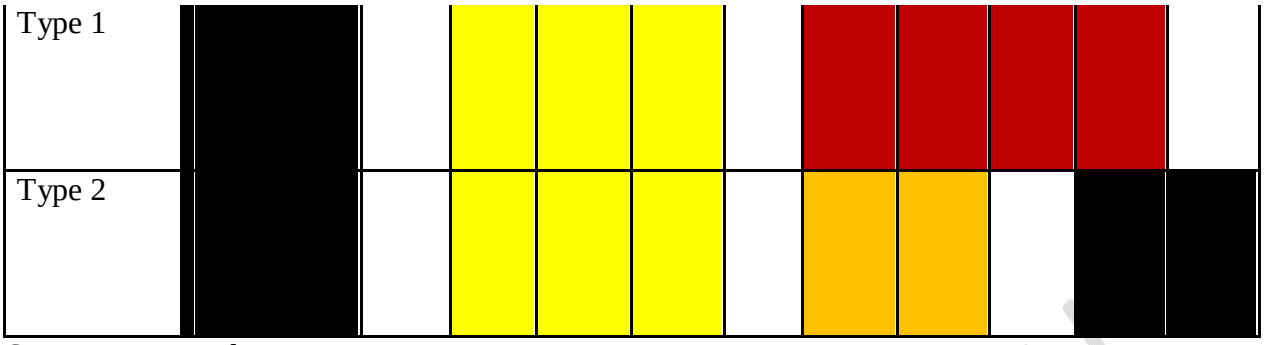


Table 4: Crop Rotation Followed by the Iceberg Lettuce Farmers

Type of rotations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec



Source: Primary data

From the figure 7, it can be interpreted that there are two types of crop rotations followed by the iceberg lettuce growing farmers in the study area. It can be noticed that after every crop the farmers are taking a one month gap for land preparation and other activities. From the above types of crop rotation, the type one crop rotation is followed by the majority of farmers i.e. 90 per cent and only 10 per cent farmers are following the type two crop rotation.

5. Conclusion

5.1 Quality Inspection:

- While harvesting, the harvesting team is not maintaining the sufficient stem length and because of that the outer two to three layers were falling off during transportation which ultimately results in the higher weight shrinkage during transportation.
- The placement of heads in the crates is not always correct in both the situations i.e. during harvesting and during dispatching. Because of this the browning problem has been observed frequently during transportation
- The crates in which the heads are being placed must be free from all types of dust and wastages but as per the observations in the study area, the crates were not clean and there are always clay spots and streaks of the lettuces.
- According to the Good Harvesting Practices (GHPs) laid down by the company, the hairnet and gloves must be used while harvesting. But the harvesting team members are not using hair nets while harvesting.
- There is also a protocol that during loading and unloading the iceberg lettuce, the gloves should be used to eliminate the human direct contact with the produce, but this rule is not properly monitored by the dispatch unit.

5.2 Cost of cultivation and crop rotation

- The total cost of cultivation was 66745 rupees/acre.
- As per the data collected in the study area, two types of crop rotations are being followed by the iceberg lettuce farmers namely,
  - Iceberg lettuce followed by beetroot followed by carrot
  - Iceberg lettuce followed by beetroot followed by broccoli followed by iceberg lettuce

6. Recommendations

As the new members have been joined in the harvesting team, they are not aware about leaving sufficient stem length of iceberg lettuce. Hence there is a need for a training programme for the new members of harvesting team about Good Harvesting Practices (GHPs). The crates in which the iceberg lettuce heads are placed must be free from all types of dust and dirt to maintain the cleanliness and to prevent the contamination. The harvesting team members must be provided with the hairnet and gloves during harvesting. And during loading and unloading also the labors must be provided with gloves and hairnet. Crop rotation should be followed by farmers which is good for better production of iceberg lettuce.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

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